THE POTENTIAL VALUE OF MECHANICAL CUTTING OF CELERY IN THE SALINAS VALLEY OF CALIFORNIA

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THE POTENTIAL VALUE OF MECHANICAL CUTTING OF CELERY IN THE SALINAS VALLEY OF CALIFORNIA

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ABSTRACT

Mechanical cutting of celery can be advantageously combined with central plant packing. On the other hand, there is very little cost advantage to be gained by mechanical cutting when combined with field packing.

INTRODUCTION

The Salinas Valley of California is a major celery-producing area. About 6,000 acres are harvested annually, beginning early in June and continuing through December. The production in the Valley amounts to about 20 percent of the total celery grown in the country.

At present, nearly all of the celery in the Salinas Valley is cut by hand and packed in the field. The operations required to meet established criteria for a good pack are identical, whether the celery is packed in the field or in a central packing plant. They are: (1) The stalk is severed from the root. (2) The butt is retrimmed if necessary. (3) Undesirable petioles are removed. (4) The top is cut off to produce a stalk of standard length. (5) Stalks are separated according to size.

HAND CUTTING WITH FIELD PACKING

Of the five operations performed on each celery stalk in preparation for packing, cutting the stalk is the most laborious. In order to estimate to what extent mechanization of the cutting of the stalks could reduce labor, a hand cut-field pack commercial celery-harvesting operation was selected for time and motion studies. These data are used to determine work rates for trimming the stalks, packing, and closing the crates.

There were 19 workers in this crew, which consisted of nine cutter-trimmers, eight packers, and two lidders or closers for the wirebound crates.

A self-propelled labor aid was used. This machine and the crew could handle nine celery beds of two rows each in each pass through the field. The cutter-trimmers placed the celery stalks on two transverse belts located on the front of the machine. These belts carried the stalks toward the center of the machine, where they were dropped onto a third belt traveling parallel to the rows. Four crate holders were on each side of the belt, for the use of eight packers. The unit was guided by the furrows between the beds. A driver was not required except when turning at the end of the field.

The cutter-trimmer cut the celery stalk by hand, trimmed the top to make the stalk about 15 inches long, removed undesirable petioles, retrimmed the butt if necessary, and laid the stalk on the belt. The packers stood on the

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ground and moved as required to keep up with the machine as it progressed through the field at a rate of approximately 4 feet per minute. Each packer packed only one size of stalk, which he visually selected as the stalks were carried past him on the belt. The filled crate was removed from the holder and placed on the ground by the packer. An empty crate was then picked up from a line of assembled crates distributed by other workers. Two workers designated as "lidders" closed and fastened the covers on the wirebound crates. The average output of this crew was 150 crates per hour.

The time and motion studies indicated that cutting the stalk from the root amounted to 40 percent of the work done by the cutter-trimmer. The remaining 60 percent consisted of stripping unwanted petioles, retrimming the butt, and trimming the top to make the stalk ready for packing.

MECHANICAL CUTTING WITH FIELD PACKING

Cutting of stalks is the most laborious, but also the most readily mechanized of the several operations. Mechanization of cutting would eliminate the stooping required for hand cutting celery.

Celery in the Salinas Valley is grown on two-row beds with a bed spacing of 40 inches. A single-row mechanical cutter-lifter traveling 2.5 miles per hour will cut celery at the rate of 475 crates per hour in a field yielding 950 crates per acre with an average row spacing of 20 inches. The rate of travel of the machine is adjusted to the rate at which the trimmers and packers can trim, grade, size, and pack the celery stalks. To realize the benefit of the machine's capacity for speed in cutting the celery stalk from the root, the other operations must be performed at matching speed. Techniques are not yet available for mechanizing the removal of undesirable petioles and trimming of the butt of the stalk.

In the 19-worker crew studied, the eight packers could pack about 150 crates per hour. Mechanization of cutting the stalk from the root would eliminate 40 percent of the work performed manually by the cutter. Therefore the number of trimmers required to supply eight packers would be 60 percent of the nine cutter-trimmers necessary to maintain an output of 150 crates per hour. Sixty percent of nine is 5.4. Six trimmers would thus be required to maintain an output of 150 crates per hour. If the same output could be achieved with 16 workers instead of 19, the production per worker would be improved 18.75 percent. However, this makes no allowance for a machine operator, who would be necessary for a machine that cuts and elevates the celery stalks. The operator would make a total of 17 workers as compared with 19, giving an improvement in labor efficiency of 11.72 percent.

This limited potential for increase in labor efficiency provides a narrow cost margin for additional equipment, but only if the same wage rate applies to the field workers whether the celery is hand cut or mechanically cut. Table 1 compares the labor efficiency for the observed hand cut-field pack system with the calculated efficiency of five hypothetical mechanical cut-field pack systems. The travel speeds indicated are based on a yield of 1,000 crates per acre with a row spacing of 20 inches. The harvest-pack rate is independent of the yield.

The hypothetical mechanical cutting systems differ from each other in the composition of the work force and the cost of equipment. The theoretical system includes a cutter-lifter mounted on a tractor, with the lifter belts delivering the mechanically cut stalks onto a conveyor belt installed on a trailed mobile platform of a size required to carry the trimmers, packers, and lidders.

The details of the design of the vehicle on which the trimming and packing is done have not been worked out. However, it is logical to assume that the cost would be roughly proportional to the number of workers for which it is designed. The cost of the vehicle plus the mechanical equipment carried by it is calculated as follows:

Initial cost . . . . . $1,000 x number of workers
Useful life. . . . . 5 years
Repairs. . . . . 10 percent of initial cost per year
Interest. . . . . 8 percent
Use per year . . . . 1,000 hours

Table 1.—Estimated rates, by number of packers in work crew, for celery harvesting by systems combining hand trimming and packing with hand or mechanical cutting and lifting

Item	Harvesting system[1]					
	Hand cut	Mechanically cut				
		Number of packers used				
	8 packers	8	7	6	5	4
Cutter-trimmers[2]	9	---	---	---	---	---
Trimmers[2]	---	6	5	4	4	3
Lidders[2]	2	2	2	2	2	1
Machine operator	---	1	1	1	1	1
Total workers	19	17	15	13	12	9
Output:						
Crates per hour[3]	150	150	131	112	94	75
Crates per man-hour	7.9	8.8	8.7	8.6	7.8	8.3
Labor efficiency (percent)	100.0	111.7	110.8	109.3	98.9	105.5
Machine and tractor cost[4]						
Dollars per hour	---	8.96	8.28	7.60	7.26	6.24
Dollars per crate	---	.06	.06	.07	.08	.08
Labor rate $2.50 per hour:						
Labor cost ($/crate)	.32	.28	.29	.29	.32	.31
Labor plus machine cost ($/crate)	.32	.34	.35	.36	.40	.39
Labor rate $4.00 per hour:						
Labor cost ($/crate)	.51	.45	.46	.46	.51	.48
Labor plus machine cost ($/crate)	.51	.51	.52	.53	.59	.56

[1] All workers are carried on a mobile platform equiped with a conveyor belt and packing aids, except the machine operator, who rides on the tractor.

[2] The number of trimmers and lidders required is calculated from the number of trimmers processing 27.77 crates per hour and lidders closing 75 creates per hour it would take to process the output per hour as determined from the number of packers.

[3] The output in crates per hour is limited by the number of packers, each of whom packs 18.75 crates per hour.

[4] The size and cost of the mobile platform and its equipment are assumed to be designed for a specific number of workers.

The initial cost of the cutter-lifter is considered to be $5,000. The fixed costs are computed on the same basis as those for the trailed vehicle. Unlike the trailed vehicle that carries the trimmers and packers, the cutter-lifter cost is independent of the number of workers. The cutter-lifter cost per hour is $1.70, and the tractor cost is $2.50 per hour.

In the five hypothetical systems compared in table 1, the maximum increase in output per worker occurs in the system that uses eight packers with mechanical cutting. It is 11.8 percent. The modest reduction in labor cost is more than cancelled by the added cost of equipment.

Even if the estimated cost of mechanical equipment were reduced by 50 percent, there would be no incentive to substitute mechanical cutting for hand cutting, other than elimination of the most strenuous task of hand cutting the celery stalks. Because hand cutting stalks is done in a stooping position, mechanization may have some value in making the work more acceptable to the workers.

The cost figures derived for the mechanical cut-field pack systems do not include all of the costs for harvesting and packing. The empty crates would have to be supplied to the vehicle that carries the trimmers, packers, and lidders. If unassembled crates are supplied, a crate assembler would have to be included in the crew. The cost of assembling and distributing the empty crates is not included with the hand cut-field pack system, so this cost is omitted in calculating the cost of the systems using mechanical cutting. Admittedly, this item would have to be included for determining the total cost of a system of harvesting and packing celery, but it is not essential to this comparison of the costs of mechanical cutting and hand cutting when combined with field packing of celery.

MECHANICAL CUTTING AND TRIMMING WITH FIELD PACKING

If trimming and stripping of stalks can be mechanized enough to reduce the labor required for these functions by 50 percent, the figures in table 2 would apply. It is emphasized that the technology on which these estimates are based has not been developed.

In table 2, the maximum estimated cost difference is between the systems of cutting and trimming by hand with eight packers, and the system of mechanized cutting and trimming with eight packers, when wages are $4.00 per hour. This maximum difference is only 8 cents per crate.

Table 2.—Estimated rates, by number of packers in work crew, for celery harvesting by an unmechanized system and by five systems that use mechanical cutting and lifting and partly mechanized trimming

Item	Harvesting system[1]					
	Hand cut	Mechanically cut and trimmed				
		Number of packers used				
	8 packers	8	7	6	5	4
Cutter-trimmers[2]	9	---	---	---	---	---
Trimmers[2]	---	3	3	2	2	2
Lidders[3]	2	2	2	2	2	1
Machine operator	---	1	1	1	1	1
Total workers	19	14	13	11	10	8
Mechanical trimming (percent)[4]	---	44	37	51	41	26
Output:						
Crates per hour[5]	150	150	131	112	94	75
Crates per man-hour	7.89	10.71	10.10	10.20	9.37	9.37
Labor efficiency (percent)	100.00	135.7	127.9	129.2	118.7	118.75
Machine and tractor cost[6]						
Dollars per hour	---	8.96	8.28	7.60	7.26	6.24
Dollars per crate	---	.06	.06	.07	.08	.08
Labor rate $2.50 per hour:						
Labor cost ($/crate)	.32	.23	.25	.25	.27	.27
Labor plus machine cost ($/crate)	.32	.29	.31	.32	.35	.35
Labor rate $4.00 per hour:						
Labor cost ($/crate)	.51	.37	.40	.39	.43	.43
Labor plus machine cost ($/crate)	.51	.43	.46	.46	.51	.51

[1] All workers are carried on a mobile platform equipped with a conveyor belt, a mechanical trimming device, and packing aids, except the machine operator, who rides on the tractor.

[2] The number of trimmers required to do by hand the trimming remaining after the machine does the indicated percentage of the trimming.

[3] The number of lidders closing 75 crates per hour it would take to process the output per hour as determined from the number of packers.

[4] The percentage of the trimming, including removal of undesirable petioles, that would have to be done mechanically to allow the indicated number of trimmers. The technology for removal of petioles mechanically has not been developed.

[5] The output in crates per hour is limited by the number of packers, each of whom packs 18.75 crates per hour.

[6] The size and cost of the mobile platform and its equipment are assumed to be designed for a specific number of workers.

MECHANICAL CUTTING WITH SHED PACKING

A cost study of celery harvesting and packing methods in Florida made by William G. Grizzell and Frederick E. Henry in 1971 compared a hand cut-field pack system with two mechanical cut-central plant pack systems.[2]

There was a substantial difference in cost between a hand cut-field pack system and the mechanical cut-shed pack systems, when based on annual outputs of one million crates. One of the central plant packing systems used electronic scales for sizing; the other used a monorail conveyor-sizer. The hand cut-field pack system used a mobile packing shed, generally referred to as a "mule train." The central plant packing systems were more economical than the field packing system with which they were compared. The saving in total harvesting, packing, and cooling costs amounted to 18.2 and 17.2 cents per crate, respectively, for the systems using the electronic sizing scale and monorail conveyor sizer. The cost saving resulted from the reduction in labor of 43 and 41 percent, respectively. Somewhat surprisingly, the same amount of labor is required for stripping and trimming the stalks in the central plant packing systems as is required for cutting, stripping, and trimming in the field with the mule train system. The major labor reductions in the central packing plant system were in packing and crate handling.

A major problem of mechanical harvesting in the Salinas Valley is that soil adheres to the butts of the celery stalks. It may be possible to modify cultural practices to solve the problem, but it is improbably that it will be done immediately. Meanwhile, the excess root and dirt must be removed from some of the celery stalks.

The most promising approach appears to be that of transfer of the stalks from the cutter-lifter mechanism of the harvester to conveyor belts where workers carried on the harvester will selectively retrim the butts of some stalks as necessary to remove dirt before they are conveyed to the truck box in which the celery is transported to the central packing plant. A power-driven rotary blade can be used for retrimming the butts.

RECOMMENDATIONS

With present technology, it is possible to develop systems of celery harvesting combining mechanical cutting with field packing. However, the cost comparisons shown in table 1 indicate there is no economic justification for the development of a functional mechanical cut-field pack system for celery. Even if the trimming and petiole stripping could be automated, mechanization of these functions would not make a field pack system superior to a mechanical cut-shed pack system.

In view of the studies published by Grizzell and Frederick and the foregoing estimates of costs for systems combining mechanical cutting with field packing, it seems evident that efforts to mechanize celery harvesting should be directed towards combining mechanical cutting with central plant packing.

A basic system in which celery is cut mechanically, dirt is removed by trimmers in the field, and the stalks are trucked to the central packing shed should be considered as a step toward the adaptation of mechanical harvesting to central plant packing under the conditions that prevail in the Salinas Valley of California. Field and crop conditions should be studied to minimize the necessity for retrimming and perhaps eliminate it altogether.

[2] Grizzell, William G., and Henry, Frederick E. A central packing-precooling system for celery. U.S. Dept. Agr., Mktg. Res. Rpt. 869. 34 pp. 1971.

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